Universität des Saarlandes, Saarbrücken, Germany

1st Year (1st and 2nd Semester)

Universität des Saarlandes (UdS), Saarbrücken Courses	ECTS-CP	Winter	Summer
Material Physics I (Horst Vehoff), lectures and exercises Contents: Bonding and crystal structure, principles of the quantum mechanics of solids, continuum waves, statistical mechanics and specific heat, point defects, diffusion, line defects and dislocations, physics of internal interfaces – grain and phase boundaries, nanocrystalline materials and composites. Prerequisites: Knowledge according to BSc. In material science or physics.	6	●	
Material Physics II (Horst Vehoff), lectures and exercises Contents: Fundamentals of irreversible thermodynamics, Nucleation and growth, recovery and recrystallisation, material strength and fracture mechanics, fatigue, creep, corrosion, surface science. Prerequisites: Knowledge according to BSc. in material science or physics. Course on Material Physics I.	6		●
Metallic Materials I / Steel (Ralf Busch / Frank Aubertin), lectures Contents: Steel groupes (unalloyed, alloyed, highly alloyed); alloying systems; Fe-C-diagram, fundamentals of phase transformation, techniques of heat treatment. Prerequisites: Knowledge according to BSc. in material science, physics or chemistry, courses in thermodynamics (constitution of materials).	3		●
Metallic Materials II / non-iron metals I (Ralf Busch / Frank Aubertin), lectures Contents: Light metals, metallurgy of Al-, Mg-, Ti-materials; properties and optimization of the properties of these metals; heavy metals; metallurgy of Cu- and Ni-materials, properties and optimisation of the properties of these metals. Prerequisites: Knowledge according to BSc. in material science, physics or chemistry, courses in thermodynamics (constitution of materials).	3	●	
Metallic Materials III / non-iron metals II (Ralf Busch / Frank Aubertin), lectures Contents: Prerequisites: Knowledge according to BSc. in material science, physics or chemistry, courses in thermodynamics (constitution of materials).	1,5		●

Universität des Saarlandes (UdS), Saarbrücken Courses	ECTS-CP	Winter	Summer
Polymer Materials (Wulff Possart), lectures Contents: Basic terms; Polymer synthesis (polymerisation, polycondensation, polyaddition); Homo- and copolymerisation; Technical processes (polymerisation in bulk, solution, suspension, emulsion and by precipitation); Properties of macromolecules (= MM): size distribution, degree of polymerisation, molecular mass, radius of gyration, constitution, isomers, conformation, collective / cooperative mobility, architecture; Structure of polymer solutions; dynamics, structure, properties of polymer melts (melting temperature, macro-conformations, interpenetrating chains, cooperative dynamics, mechanical behaviour); Structures in solid polymers: molecular interactions and shape of the MM, glass transition, amorphous structure, crystalline morphologies (lamella, extended chains and fibrils, defects), suprastructures (spherulit, dendrit, shish-kebab, epitaxy); Heterogeneous systems (plasticitation, mixtures, copolymers); Material properties – Part I: thermal behaviour (specific heat capacity, thermal glass transition, melting / crystallisation, heat conduction, thermal expansion), mechanics at small periodic deformation (linear viscoelasticity, static and dynamic glass transitions, WLF-equation); Polymer processing (extrusion, spinning, injection moulding, pressing, vacuum forming, calender, foaming, lamination, coating); Material properties – Part II: mechanical properties (relaxation and retardation, influence of temperature, t-T-superposition principle, non-linear deformation, microscopic crack development, technical characterisation, internal tensions), electric properties (polarisation and conductivity – microscopic mechanisms and processes, dielectric relaxation, electrical-mechanical analogy, electrostatic charging, electric breakdown, leakage currents, conducting polymers). Prerequisites: Basics of general, organic and technical chemistry, basics of experimental physics including thermodynamics.	3	●	
Ceramics I (NN), lectures Contents: Classification of Ceramic Materials; Basics of Silicate Ceramics: Quartz, Kaoline, Feldspars, Glass formation; Shaping Technologies: Molding, Plastic Forming, Dry Pressing Technique; Firing: Sintering Processes; Porcellain; Basics of Engineering Ceramics: Mechanical, Thermal, and Corrosions Properties; Processing; Fabrication Technology. Prerequisites: Knowledge according to BSc. in material science, physics or chemistry.	3	●	
Glass I – Fundamentals (Rolf Clasen), lectures Contents: Literature review; history of glass materials; glass structures and models; non-silicate glasses; metallic glasses; preparation and devitrification of glasses; physical and chemical properties of technical glasses, e. g. density, viscosity, mechanical, thermal, electrical and optical properties; applications. Prerequisites: Knowledge according to BSc. in material science, physics or chemistry. Course(s) in Material Physics useful.	4,5		●
3D-Analysis of Micro- and Nano-Structures (Frank Mücklich), lectures and exercises Contents: most of the materials properties depend on the local 3D formation of phases, interphases as well as various lattice defects (up to micro precipitations or pores). The course includes lectures as well as practical training at research facilities concerning: precise 3D target preparation in the nano scale, serial sectioning and 3D reconstruction, improved possibilities of chemical and structural analytics in the "nanolab" (FIB+REM+STEM+EDX+EBSD); 2D image analysis and 3D reconstruction by stereology in homogeneous materials. Prerequisites: Knowledge according to BSc. in material science or physics.	3	●	

Universität des Saarlandes (UdS), Saarbrücken Courses	ECTS-CP	Winter	Summer
Analysis of Micro- and Nano-Structures with Diffraction Methods (Frank Mücklich), lectures and exercises Contents: Analysis of phases and defects in single- and poly-crystalline materials by diffraction techniques with high resolution; residual stresses, texture; diffractometry as well as topography with X-ray and Synchrotron radiation; high resolution lattice parameter measurement, local orientation and phase mapping with electron back scattering diffraction (EBSD), high resolution analysis by nanometer preparation with Focused Ion Beam Microscopy (FIB, STEM); exercises using high resolution 7-axis X-ray diffractometer Philips XPert and the nanotechnological DualBeam Workstation Strata DB 235 (FEI). Prerequisites: Knowledge according to BSc. in material science or physics.	4,5		●
Material Science Methods I (Horst Vehoff), lectures Contents: Fundamentals of microscopy and spectroscopy, scanning electron microscopy, electron spectroscopy (EDX and microprobe), transmission electron microscopy, principles of electron diffraction, theory of electron diffraction, scanning probe microscopy, field ion microscopy, small angle scattering. Prerequisites:	3		●
Non-Destructive Testing of Materials I or II (Michael Kröning / Walter Arnold), lectures Contents: Basics of Electromagnetism: Electric and magnetic field and related properties; Dia-, para- and ferromagnetism; polarization of materials in E- and H-fields; Magnetic domains and Bloch walls; Maxwell equations; Skineffect. Basics of Oscillations and Waves: Oscillations with one and several degree of freeedom; modulation; Dispersion; Longitudinal and transverse waves; Wave equation; Group and phase velocity; Fourier-transformation of signals; eelastic moduli; Reflection, transmission, piston source; Near-field; far-field. Applications and Techniques of NDT: Rules for application of ultrasonic NDT- methods; certification; validation; Principles of ultrasonic testing apparatuses; Techniques for measuring attenuation and time-of-flight; Defect determination using DGS-diagrams. Prerequisites: Knowledge according to BSc. in material science or physics.	3	●	●
Laboratory on Non-Destructive Testing of Materials (Michael Kröning / Walter Arnold), laboratory work Contents: Determination of defect sizes by DGS-diagrams; A, B, C-scanning techniques; Testing of plates with lamb waves; Determination of elastic moduli and mechanical stresses by measuring ultrasonic time-of-flight; Grain-size determination using ultrasonic backscattering; Eddy current testing; Leakage flux; Barkhausen noise measurement; Hysterese evaluation; X-Ray testing. Prerequisites: Lectures on Non-Destructive Testing.	3	●	●
Experimental Characterization of Polymer Materials (Wulff Possart), exercises, seminar, laboratory work Contents: Dynamic-mechanical analysis; ultrasound; thermo-gravimetric analysis; calorimetry; dielectric spectroscopy; neutron and x-ray diffraction; nuclear magnetic resonance spectroscopy (NMR); infrared and Raman spectroscopy; technical test methods. Prerequisites: Course Polymer Materials, basics of experimental physics; recommended: basics of non-destructive testing of materials.	3		●
Continuum Mechanics (Stefan Diebels), lectures and exercises Contents: Introduction, kinematics, balance relations, modelling of material behaviour, constitutive equations; elastic solids, viscous fluids, plasticity. Prerequisites: Knowledge in technical mechanics (BSc. level).	4,5	●	

Universität des Saarlandes (UdS), Saarbrücken Courses	ECTS-CP	Winter	Summer
Finite Elements in Mechanics I (Wolfgang Ripplinger), lectures and exercises Contents: Approximation procedures, linear elasticity, 1-, 2- and 3-D elements, computational procedures, mesh generation and adaptive meshing, bandwidth optimization, system equation, dynamics. Prerequisites: Knowledge in technical mechanics (BSc. level).	4,5	●	
Laboratory on Finite Element Analysis (Christian Weber), laboratory work Contents: Selected cases of modelling and analysing the mechanical behaviour of materials, components and processes using a commercial FEA system. Prerequisites: Knowledge in technical mechanics (BSc. level); basic knowledge in CAD/CAE.	3	●	
Mechanical Properties of Materials (Ralf Busch), lectures Contents: Mechanisms of deformation of metallic materials; influence of the deformation parameters: rate of deformation, degree of deformation, temperature, stress rate, influence of the material; mechanisms of hardening: solid solution, precipitation, dispersion, cold deformation, grain refinement, texturing; examples for thermomechanical treatment; material selection. Prerequisites: Knowledge according to BSc. in material science, physics or chemistry, courses in mechanics.	3	●	
Laboratory on Mechanical Properties (Ralf Busch / Frank Aubertin), laboratory work Contents: Methods of metallography; thermal analysis; solidificaton of metallic melts; tension test (tempering diagram of steels); fatigue strength; R-value; impact test; hardness measurement; (hardening) measurement of the electrical conductivity; thermal expansion and phase transformation (dilatometry). Prerequisites: Knowledge according to BSc. in material science, physics or chemistry, courses in mechanics; Lectures on Mechanical Mroperties of Materials.	3		●
Functional Materials I (Frank Mücklich), lectures and exercises Contents: Introduction and overview over “smart materials”; phase transformations in solids; thermodynamics of phase transformations; martensitic transformation; shape-memory-materials; polarisation in dielectrics; piezo-electric, magneto-strictive materials; optical materials. Prerequisites: Knowledge according to BSc. in material science or physics.	4,5	●	
Functional Materials II (Frank Mücklich), lectures and exercises Contents: Magnetic materials (magnetism, macroscopic and microscopic effects, design of magnetic properties, soft and hard magnetic materials); conducting materials (materials and electron conductivity, super conductivity, ion conductivity); semiconductors, band structure, lattice defects and related electrical effects, element and compound semiconductors, bandgap engineering; example Si and GaAs – technology, crystal growth, structuring. Prerequisites: Knowledge according to BSc. in material science or physics.	4,5		●
Cutting, Electrical and Chemical Machining (Bley), lectures Contents: Prerequisites:	3	●	
Glass II – Processing (Rolf Clasen), lectures Contents: Melting of glass, reactions; furnaces for glass melting, refractive materials, production of glass bottles and flat glass; recycling of glass, production of vitreous silica glass and glass for special applications, coating of glass, especially for saving energy; productions faults of glass, mechanical shaping of glass. Prerequisites: Course in Glass I.	3	●	

Universität des Saarlandes (UdS), Saarbrücken Courses	ECTS-CP	Winter	Summer
Ceramic Processing (Rolf Clasen), lectures Contents: Preparationd and characterization of ceramic powders, dispersing; fundamentals of colloids, rheology; influence of of additives; shaping processes from low-viscosity suspensions (slip casting, electrophoresis, foil casting), preparation of high-viscous slips for extrusion and injection moulding; drying of compacts, debindering and purification, characterisation of green compacts; sintering processes: furnaces, IR-radiation, microwaves. Prerequisites: Knowledge in Ceramics.	3	●	
Adhesives and Adhesive Technology (Wulff Possart), lectures Contents: Raw materials (animal and plant glues, inorganics, elastomers, network-forming reactive systems, linear polymers, radiation-curing polymers, fillers, primers, adhesion promoters); Surface treatment of adherends (chemical and physical treatment procedures for metals, polymers, glass); Adhesives and their selection (pressure-sensitive adhesives (PSA), hot melt adhesives, solvent-based adhesives, adhesive dispersions, chemically reactive adhesives, temperature-resistant adhesives, electrically conducting adhesives, heat-conducting adhesives); Fundamental adhesion (intermolecular interactions in condensed phases – summary, polymers at phase boundaries, mechanical model of adhesion, electrostatic component of adhesion, thermodynamics of heterogeneous systems – the phase boundary, wetting and contact angle measurement, thermodynamic models of adhesion, chemical adhesion interactions). Prerequisites: Course Polymer Materials, basics of experimental physics; recommended: basics of solid state physics.	3		●
Micro- and Nano-Structuring of Materials (Rolf Clasen), lectures Contents: Overview nanotechnology, strategies for micro/nano structuring of materials in case of particles, surfaces and bulk, biomimetic approaches, thin film preparation and structuring, field enhanced methods; lithographic and interference methods, scanning probe methods. Preparation of compacts and coating from nanoparticles, characterization of powders and compacts, specific approaches for metals, glass and ceramics, polymers, carbon in case of fullerenes and nanotubes, Prerequisites: Knowledge according to BSc. in material science or physics.	3		●
Plasticity (Stefan Diebels / Wolfgang Ripplinger), lectures Contents: Yield criterion, plastic potential, flow rule, hardening rules, slip-line theory, limit theorems, applications: bending, forging, rolling, extrusion, numerical treatment. Prerequisites: Knowledge in technical mechanics (BSc. level); course in continuum mechanics.	3		●
Seminar: To be selected from several seminars covering particular research fields. Prerequisites: Lectures/exercises/laboratory work in the field.	3		●

Universität des Saarlandes

2nd Year (3rd and 4th Semester)

Universität des Saarlandes (UdS), Saarbrücken Courses	ECTS-CP	Winter	Summer
Material Physics I (Horst Vehoff), lectures and exercises Contents: Bonding and crystal structure, principles of the quantum mechanics of solids, continuum waves, statistical mechanics and specific heat, point defects, diffusion, line defects and dislocations, physics of internal interfaces – grain and phase boundaries, nanocrystalline materials and composites. Prerequisites: Knowledge according to BSc. in material science or physics.	6	●	
Non-Destructive Testing of Materials II (Michael Kröning / Walter Arnold), lectures Contents: Basics of Electromagnetism: Electric and magnetic field and related properties; Dia-, para- and ferromagnetism; polarization of materials in E- and H-fields; Magnetic domains and Bloch walls; Maxwell equations; Skineffect. Basics of Oscillations and Waves: Oscillations with one and several degree of freeedom; modulation; Dispersion; Longitudinal and transverse waves; Wave equation; Group and phase velocity; Fourier-transformation of signals; eelastic moduli; Reflection, transmission, piston source; Near-field; far-field. Applications and Techniques of NDT: Rules for application of ultrasonic NDT- methods; certification; validation; Principles of ultrasonic testing apparatuses; Techniques for measuring attenuation and time-of-flight; Defect determination using DGS-diagrams. Prerequisites: Knowledge according to BSc. in material science or physics.	3	●	
Laboratory on Non-Destructive Testing of Materials (Michael Kröning / Walter Arnold), laboratory work Contents: Determination of defect sizes by DGS-diagrams; A, B, C-scanning techniques; Testing of plates with lamb waves; Determination of elastic moduli and mechanical stresses by measuring ultrasonic time-of-flight; Grain-size determination using ultrasonic backscattering; Eddy current testing; Leakage flux; Barkhausen noise measurement; Hysterese evaluation; X-Ray testing. Prerequisites: Lectures on Non-Destructive Testing.	3	●	
Mechanical Properties of Materials (Ralf Busch), lectures Contents: Mechanisms of deformation of metallic materials; influence of the deformation parameters: rate of deformation, degree of deformation, temperature, stress rate, influence of the material; mechanisms of hardening: solid solution, precipitation, dispersion, cold deformation, grain refinement, texturing; examples for ther-momechanical treatment; material selection. Prerequisites: Knowledge according to BSc. in material science, physics or chemistry, courses in mechanics.	3	●	
Metallic Materials II / non-iron metals I (Ralf Busch / Frank Aubertin), lectures Contents: Light metals, metallurgy of Al-, Mg-, Ti-materials; properties and optimization of the properties of these metals; heavy metals; metallurgy of Cu- and Ni-materials, properties and optimisation of the properties of these metals. Prerequisites: Knowledge according to BSc. in material science, physics or chemistry, courses in thermodynamics (constitution of materials).	3	●	

Universität des Saarlandes (UdS), Saarbrücken Courses	ECTS-CP	Winter	Summer
Polymer Materials (Wulff Possart), lectures Contents: Basic terms; Polymer synthesis (polymerisation, polycondensation, polyaddition); Homo- and copolymerisation; Technical processes (polymerisation in bulk, solution, suspension, emulsion and by precipitation); Properties of macromolecules (= MM): size distribution, degree of polymerisation, molecular mass, radius of gyration, constitution, isomers, conformation, collective / cooperative mobility, architecture; Structure of polymer solutions; dynamics, structure, properties of polymer melts (melting temperature, macro-conformations, interpenetrating chains, cooperative dynamics, mechanical behaviour); Structures in solid polymers: molecular interactions and shape of the MM, glass transition, amorphous structure, crystalline morphologies (lamella, extended chains and fibrils, defects), suprastructures (spherulit, dendrit, shish-kebab, epitaxy); Heterogeneous systems (plasticitation, mixtures, copolymers); Material properties – Part I: thermal behaviour (specific heat capacity, thermal glass transition, melting / crystallisation, heat conduction, thermal expansion), mechanics at small periodic deformation (linear viscoelasticity, static and dynamic glass transitions, WLF-equation); Polymer processing (extrusion, spinning, injection moulding, pressing, vacuum forming, calender, foaming, lamination, coating); Material properties – Part II: mechanical properties (relaxation and retardation, influence of temperature, t-T-superposition principle, non-linear deformation, microscopic crack development, technical characterisation, internal tensions), electric properties (polarisation and conductivity – microscopic mechanisms and processes, dielectric relaxation, electrical-mechanical analogy, electrostatic charging, electric breakdown, leakage currents, conducting polymers). Prerequisites: Basics of general, organic and technical chemistry, basics of experimental physics including thermodynamics.	3	●	
Ceramics I (NN), lectures Contents: Contents: Classification of Ceramic Materials; Basics of Silicate Ceramics: Quartz, Kaoline, Feldspars, Glass formation; Shaping Technologies: Molding, Plastic Forming, Dry Pressing Technique; Firing: Sintering Processes; Porcellain; Basics of Engineering Ceramics: Mechanical, Thermal, and Corrosions Properties; Processing; Fabrication Technology. Prerequisites: Knowledge according to BSc. in material science, physics or chemistry.	3	●	
Ceramic Processing (Rolf Clasen), lectures Contents: Preparationd and characterization of ceramic powders, dispersing; fundamentals of colloids, rheology; influence of of additives; shaping processes from low-viscosity suspensions (slip casting, electrophoresis, foil casting), preparation of high-viscous slips for extrusion and injection moulding; drying of compacts, debindering and purification, characterisation of green compacts; sintering processes: furnaces, IR-radiation, microwaves. Prerequisites: Knowledge in Ceramics.	3	●	
Glass II – Processing (Rolf Clasen), lectures Contents: Melting of glass, reactions; furnaces for glass melting, refractive materials, production of glass bottles and flat glass; recycling of glass, production of vitreous silica glass and glass for special applications, coating of glass, especially for saving energy; productions faults of glass, mechanical shaping of glass. Prerequisites: Course in Glass I.	3	●	
Continuum Mechanics (Stefan Diebels), lectures and exercises Contents: Introduction, kinematics, balance relations, modelling of material behaviour, constitutive equations:; elastic solids, viscous fluids, plasticity. Prerequisites: Knowledge in technical mechanics (BSc. level).	4,5	●	

Universität des Saarlandes (UdS), Saarbrücken Courses	ECTS-CP	Winter	Summer
Finite Elements in Mechanics I (Wolfgang Ripplinger), lectures and exercises Contents: Approximation procedures, linear elasticity, 1-, 2- and 3-D elements, computational procedures, mesh generation and adaptive meshing, bandwidth optimization, system equation, dynamics. Prerequisites: Knowledge in technical mechanics (BSc. level).	4,5	●	
Laboratory on Finite Element Analysis (Christian Weber), laboratory work Contents: Selected cases of modelling and analysing the mechanical behaviour of materials, components and processes using a commercial FEA system. Prerequisites: Knowledge in technical mechanics (BSc. level); basic knowledge in CAD/CAE.	3	●	
Optics and Anorganic Layers (Michael Aegerter), lectures Contents: Basics: Light; optical materials, interaction of light and matter. Coating: introduction; coating technologies; substrates and materials; film production and structure; characterization techniques; physical properties (mechanical, optical, electrical, etc.). Filter: design; characteristics and measurements, applications. Future materials; outlook. Prerequisites: Basic Physics (optics, thermodynamics, gas kinetic theory), basic inorganic chemistry, materials characterisation.	3	●	
Functional Materials I (Frank Mücklich), lectures and exercises Contents: Introduction and overview over “smart materials”; phase transformations in solids; thermodynamics of phase transformations; martensitic transformation; shape-memory-materials; polarisation in dielectrics; piezo-electric, magneto-strictive materials; optical materials. Prerequisites: Knowledge according to BSc. in material science or physics.	4,5	●	
Master Thesis (Compulsory) To be selected from the research laboratories’ scientific or industry-related projects. Prerequisites: Lectures/exercises/laboratory work in the field.	30		●